Front Resolving Observational Network with Telemetry (FRONT)

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LONG-TERM GOALS

We're developing a cost-effective observation and prediction system for a dynamically complex region of the coastal ocean. Data-assimilative dynamical and biological models provide an integral part of the system. The models will assimilate data from a variety of in situ and remote sensors. Data telemetry to shore will use a wireless communications network. Our long-term goal is to implement and test a data-assimilative observation system that mitigates effects of undersampling, and allows forecasting of physical and biological fields.

OBJECTIVES

We are installing the Front Resolving Observational Network with Telemetry (FRONT) on a portion of continental shelf south of the eastern end of Long Island, New York (Figure 1A, below). Historical observations indicate that variable bathymetry and strong tides interact with energetic wind- and buoyancy-forced motions to produce recurring fronts. For example, Figure 1A shows SeaWiFS chlorophyll concentration (yellow high, blue low) with a sharp gradient in the middle of the FRONT site (the square subdomain). Our objective is to develop and test the observation system in this complex dynamical regime.

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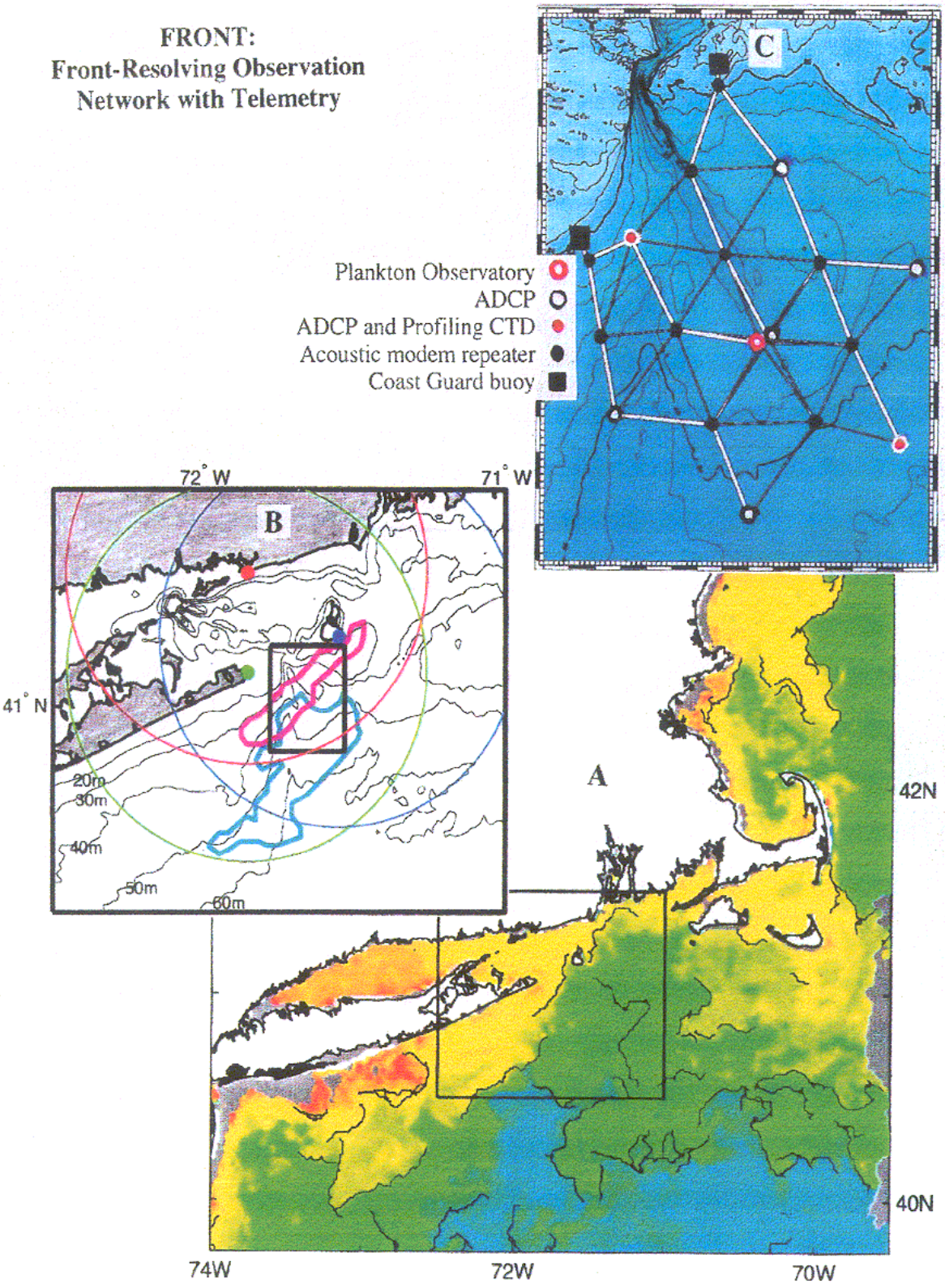

Figure 1: Three different magnifications of the FRONT site. A: SeaWiFS image. B: Bathymetry contours with CODAR range circles. C: In situ array with sensor locations.

Technical objectives include coordination and telemetry of real-time data streams from a combination of in situ instruments including ADCP's, profiling CTD's, and an Autonomous Vertically Profiling

Plankton Observatory (AVPPO). The array will sample the smaller domain within Figure 1B. Figure 1C (upper right) shows this smaller domain along with sensor and modem locations, and interconnecting acoustic paths. The blue and magenta contours in Figure 1B show regions where fronts occur with high probability in July (blue) and January (magenta) based on 12 years of AVHRR data.

Shore-based CODAR will provide real-time measurement of surface current. The circles in Figure 1B show overlapping ranges for 3 stations. Satellite data will provide large-scale coverage of sea-surface temperature and color.

We are setting up a high-resolution version of the MIT general circulation model (MITgcm) for the square region in Figure 1B. Our objective is to comprehensively address dynamics in the region of strong frontal activity. We also anticipate a fascinating interaction between the fluid mechanics and the biogeochemistry of the fronts.

APPROACH

Data telemetry and instrument control will be accomplished with a wireless underwater communications network. The network features multiple acoustic modems connected in a topology that can tolerate failure or loss of individual elements. Joe Rice of Space and Naval Warfare Systems Center at San Diego (SSC-SD) is working toward this goal. Rice is a PI on the FRONT team with an independent award. Dan Codiga (University of Connecticut) is coordinating the physical oceanographic instrumentation with the Navy's acoustic network.

Scott Gallager, Heidi M. Sosik, and Cabell S. Davis (all at Woods Hole Oceanographic Institution) will be deploying the AVPPO, integrating it into the acoustic network, and analyzing and preparing the data for integration into the biological assimilative model.

John Marshall (Massachusetts Institute of Technology) and Sonya Legg (Woods Hole Oceanographic Institution) will work with Philip Bogden to set up the MIT model for the frontal environment. We will use MITgcm together with its tangent linear, adjoint, and open-boundary capability for data assimilation. Marshall's group at MIT has put enormous effort into the development of non-hydrostatic ocean models that can operate across the scales of motion that are the focus of FRONT. Legg, in particular, has been developing the open-boundary capabilities in idealized studies of boundary mixing associated with critical-angle internal-wave reflection off sloping bathymetry.

The high-resolution non-hydrostatic model will be embedded within an even larger scale barotropic inverse model of the entire New York Bight and lower Gulf of Maine. Bogden will be working with a post-doctoral researcher to provide accurate tidal and sub-tidal boundary conditions for MITgcm. This will provide an efficient and computationally economical first step in assimilating the real-time data streams into the more dynamically complex MITgcm.

Mick Follows (MIT), in collaboration with biologists Gallager, Sosik, and Davis at WHOI, and Petra Stegmann (University of Rhode Island), will embed an appropriate regional ecosystem model within the frontal model of Legg and Bogden. With the combined modeling effort we will synthesize the physical and biological data to advance our understanding of the biological interactions on frontal scales.

Remotely sensed surface current maps from CODAR will provide an important supplement to the in situ array. Don Barrick and Belinda Lipa (both with CODAR Ocean Sensors, Ltd.) will assist in the

improvement of signal-processing algorithms for using CODAR. This will help CODAR become an integral part of the assimilative models.

Jim O'Donnell (UConn) and Dave Hebert (URI) will coordinate ship surveys that are designed to provide high resolution verification and testing of the observation system in regions of strong frontal activity. O'Donnell is developing a new instrument array designed to resolve the small-scale frontal features that will remain undersampled by the moored instruments and unresolved by the models.

Verification and testing activities include turbulence measurements by FRONT partners at University of Rhode Island, and the Naval Undersea Warfare Center in Newport, Rhode Island. These activities will test the accuracy of the model's sub-grid scale parameterizations.

The United States Coast Guard Research and Development Center is providing substantial supplementary support for the project. This includes a series of surface-drifter deployments in the FRONT region to be coordinated by Jennifer Dick (USCG).

WORK COMPLETED

Successful tests of the acoustic modem communications have already occurred. A preliminary test has demonstrated the transmission of data from a bottom-mounted ADCP via acoustic modem to a cell-phone modem, to a Bell Atlantic server, and then over the Internet to UConn. The US Coast Guard has provided critical support for using existing navigational aids as instrument platforms. The Coast Guard is also providing valuable support for the installation of CODAR at shore-based lighthouses.

RESULTS

At the time of writing, the project is only 2 months old. The major results so far relate to the testing of underwater communications capabilities described above. Modeling and equipment acquisition activities are also underway.

IMPACT/APPLICATIONS

The FRONT observation capability will be transportable to any region of the coastal ocean. The planned technological refinements will facilitate rapid deployment and remote-sensing capabilities for a wide range coastal environments. The dynamical complexity of the FRONT site provides a special challenge to this kind of observation system.

The satellite AVHRR analysis of FRONT partners Ullman and Cornillon (1999), both of University of Rhode Island, provides compelling evidence that the dynamical processes occurring at the FRONT site may exist along coastlines around the world. This underscores the need to understand and observe such a regime.

TRANSITIONS

The FRONT experiment schedule includes planned outages during which the fielded network may be used by SSC-SD to test prototype deployable sensors for surveillance, and other autonomous undersea devices, including mobile network nodes such as AUV's. The concomitant knowledge of the ocean structure provided by the FRONT system will allow SSC-SD to diagnose the relationships between network performance and the environment.

RELATED PROJECTS

FRONT is part of the National Oceanographic Partnership Program (NOPP). The project includes participation of scientists at University of Rhode Island (URI), National Undersea Warfare Center (NUWC) in Newport, Rhode Island, an SSC-SD. Dave Hebert (URI), Ed Levine (NUWC) and Joe Rice (SSC-SD) are the lead PI's on the related Awards.